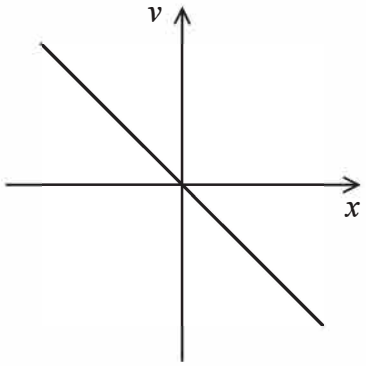
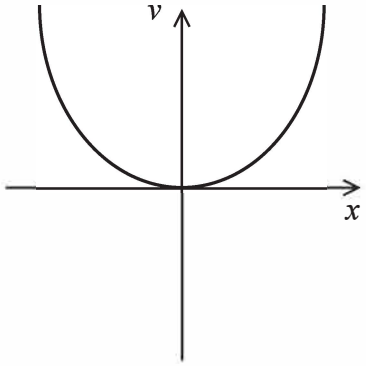
10 A mass at the end of a spring is set into small amplitude simple harmonic motion.

Which of the following graphs correctly shows the variation of velocity v of the mass with displacement x for one complete oscillation?

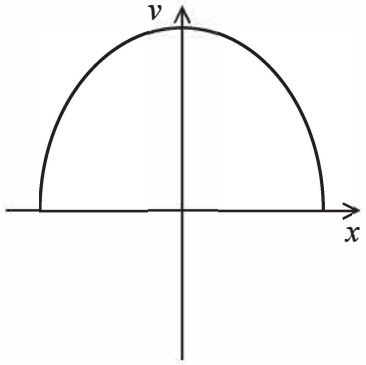
☒ **A**



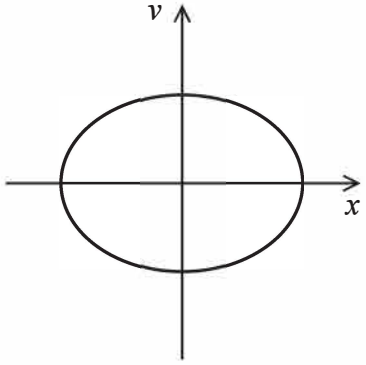
☒ **B**



☒ **C**



☒ **D**



(Total for Question 10 = 1 mark)

16 The photograph shows an example of a Foucault pendulum.

This is a pendulum that consists of a massive sphere, suspended by a long wire from a high ceiling. Over time the vertical plane through which the pendulum swings appears to rotate because of the rotation of the Earth.

mass of sphere = 28.0 kg

(a) The pendulum makes 8 complete oscillations in 52.2 s.

Show that the length of the wire supporting the sphere is about 10 m.

diameter of sphere = 60.0 cm

(4)

(b) During refurbishment, the pendulum is taken down and the wire is replaced.

Steel wires of the following diameters are available:

0.71 mm 0.91 mm 1.22 mm 1.63 mm 2.03 mm

(i) Explain which of these wires is the thinnest that could be used to support the sphere safely.

breaking stress of steel = 3.10×10^8 N m^{-2}

(3)

(ii) The wire identified in part (i) is used for the pendulum, the unstretched length of the new wire is 11.2 m.

Calculate the extension of the new wire when the sphere is attached.

Young Modulus for steel = 200 GPa

(3)

Extension = ...

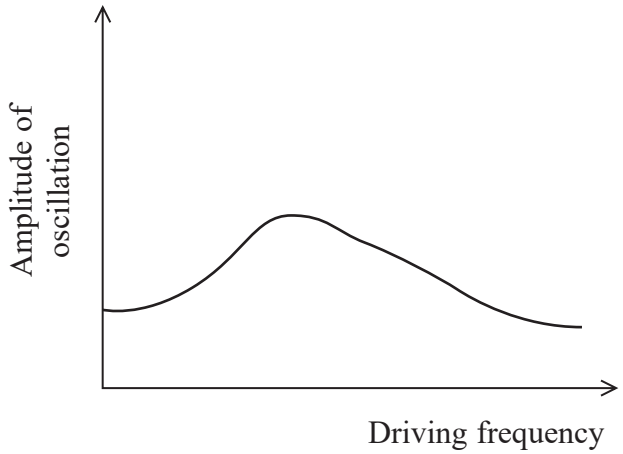
(c) To show the rotation of the Earth, the pendulum needs to oscillate for several hours.

Explain how using a heavy sphere is better than using a light sphere of the same diameter.

(3)

(Total for Question 16 = 13 marks)

5 A damped mass-spring system is driven into oscillation. The graph shows the amplitude of oscillation as the driving frequency is varied.



The damping is decreased.

Which row of the table describes what happens to the maximum amplitude of oscillation and the driving frequency at which this occurs?

	Maximum amplitude	Frequency at which maximum amplitude occurs
☒ **A**	decreases	decreases
☒ **B**	decreases	increases
☒ **C**	increases	decreases
☒ **D**	increases	increases

(Total for Question 5 = 1 mark)

6 A proton can be considered to be both a point charge and a point mass. There is an electric field and a gravitational field associated with the proton.

Which of the following statements about the fields is **not** correct?

☒ **A** Field strength is a vector.

☒ **B** Potential is always less than 0.

☒ **C** Potential is proportional to $\frac{1}{\text{distance from proton}}$

☒ **D** Field strength is proportional to $\frac{1}{(\text{distance from proton})^2}$

(Total for Question 6 = 1 mark)

7 A pendulum of length l with a bob of mass m oscillates with frequency f.

What is the frequency of a pendulum of length $4l$ with a bob of mass $2m$?

☒ **A** $4f$

☒ **B** $2f$

☒ **C** f

☒ **D** $\frac{f}{2}$

(Total for Question 7 = 1 mark)

8 Which of the following lenses would produce a real image of an object placed 15 cm away from the lens?

☒ **A** converging, focal length = 10 cm

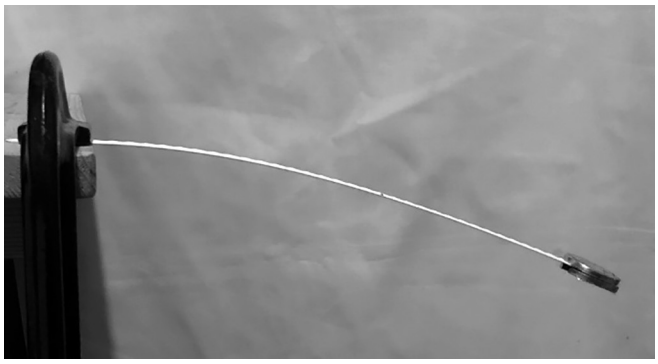
☒ **B** converging, focal length = 20 cm

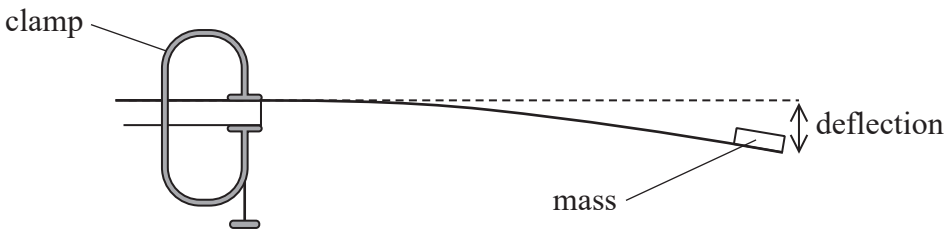
☒ **C** diverging, focal length = 10 cm

☒ **D** diverging, focal length = 20 cm

(Total for Question 8 = 1 mark)

13 A student measured the deflection of a mass attached to the end of a thin strip of metal.
The strip was clamped to a bench at one end as shown.

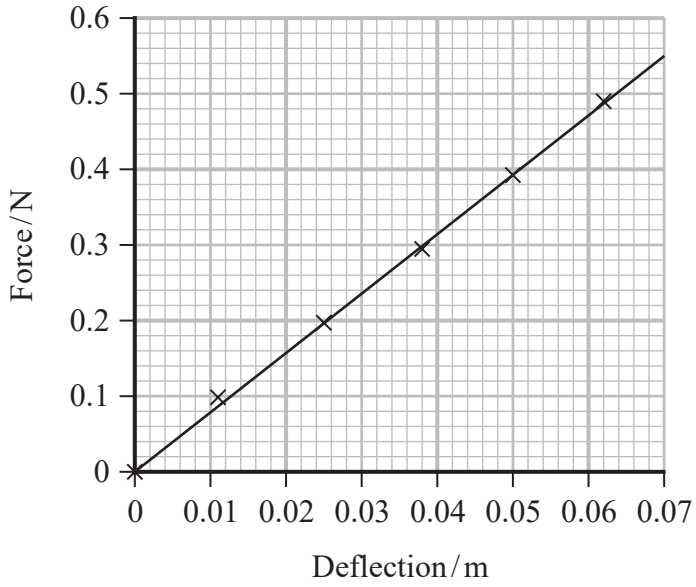




The student varied the force on the end of the strip by changing the mass attached.

The deflection was measured each time when the mass was in its equilibrium position.

The student obtained the following graph of deflection against force.



(a) State why the mass will oscillate with simple harmonic motion when it is displaced slightly from its equilibrium position and released.

(2)

(b) The student then investigated the oscillations of the mass on the metal strip. The student fixed different numbers of 10 g masses to the end of the metal strip.

The student noticed that the smaller the mass the higher the frequency of the oscillations. He estimated that the maximum number of oscillations he could count was two per second. He decided that the smallest mass he should use was 50 g.

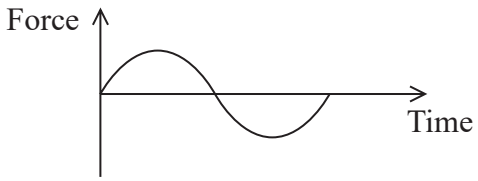
Determine whether 50 g is the smallest mass he should use.

You may assume that the system acts in the same way as a mass on a spring.

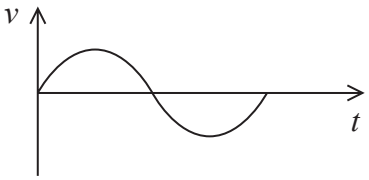
(5)

(Total for Question 13 = 7 marks)

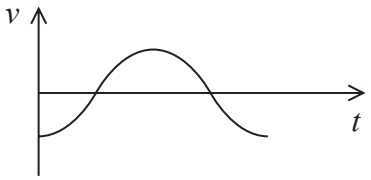
9 A mass is suspended from a spring and allowed to come to equilibrium.
The mass is displaced vertically and moves with simple harmonic motion.
The graph shows how the resultant force on the mass varies with time.



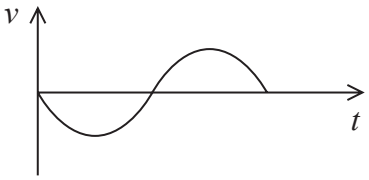
Which of the following graphs shows how the velocity v of the mass varies with time t over the same time interval?



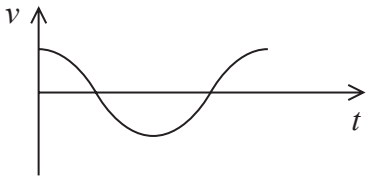
A



B



C



D

☒ **A**

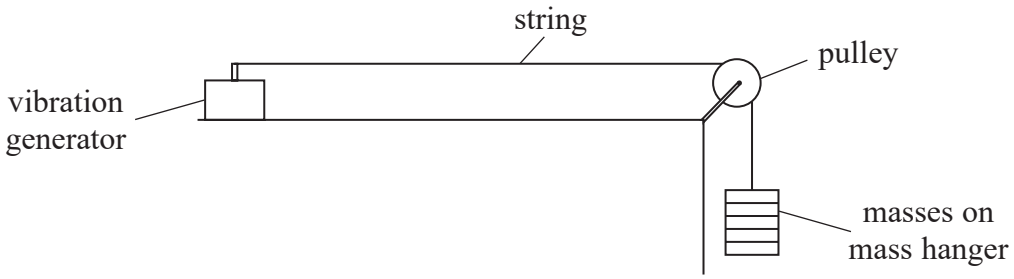
☒ **B**

☒ **C**

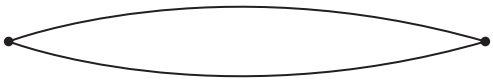
☒ **D**

(Total for Question 9 = 1 mark)

10 The diagram represents an arrangement used to generate standing waves on a string.



A standing wave pattern with two nodes is obtained as shown.



Which of the following single changes could produce a standing wave pattern with three nodes?

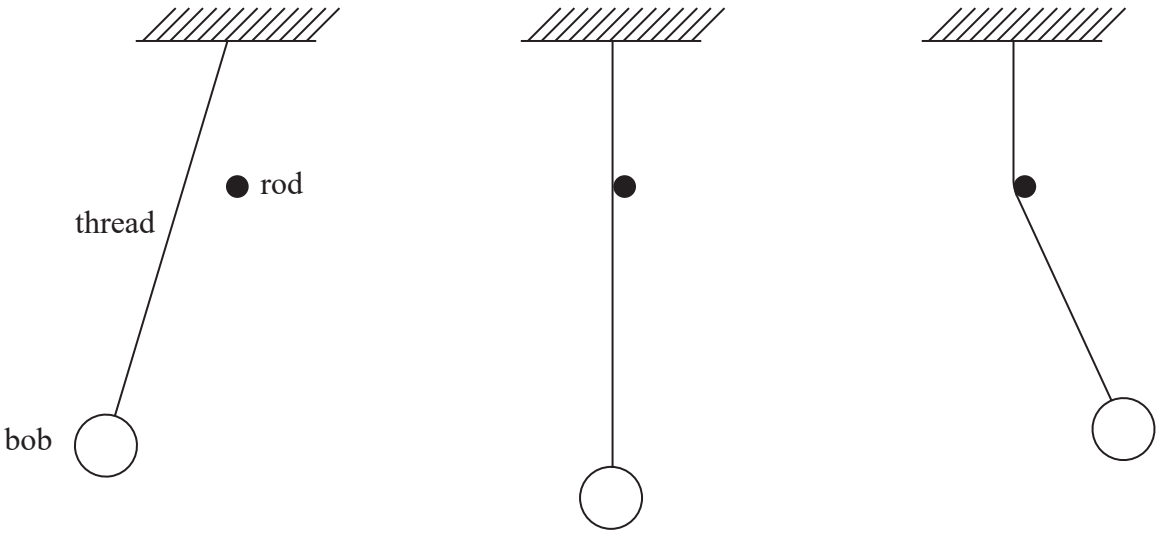
- ☒ **A** decreasing the distance between the vibration generator and pulley
- ☒ **B** decreasing the frequency of the vibration generator
- ☒ **C** decreasing the mass on the mass hanger
- ☒ **D** decreasing the mass per unit length of the string

(Total for Question 10 = 1 mark)

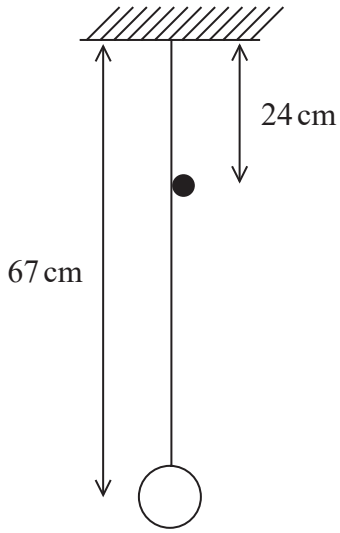
11 A simple pendulum consisting of a thread and a bob is set up next to a horizontal rod.

The bob is displaced to the left and released. When the bob reaches the equilibrium position the thread strikes the horizontal rod. For half of the cycle, only the lower part of the pendulum moves.

The diagram shows the swing of the pendulum.



The diagram below shows the dimensions of the pendulum.



Determine the frequency of the oscillations of the pendulum.

Frequency = ...

(Total for Question 11 = 4 marks)

18 The harp is a musical instrument with many strings, as shown.

(Source: © Peter Voronov/Shutterstock)

All the strings are under tension.

The strings on one type of harp are made from nylon of density $1070\,\text{kg}\,\text{m}^{-3}$. One string has a diameter of $1.14\,\text{mm}$.

(a) (i) Show that the mass per unit length μ of the string is about $1.1 \times 10^{-3}\,\text{kg}\,\text{m}^{-1}$.

(2)

(ii) When the middle of the string is plucked, a note of frequency 440 Hz is produced.

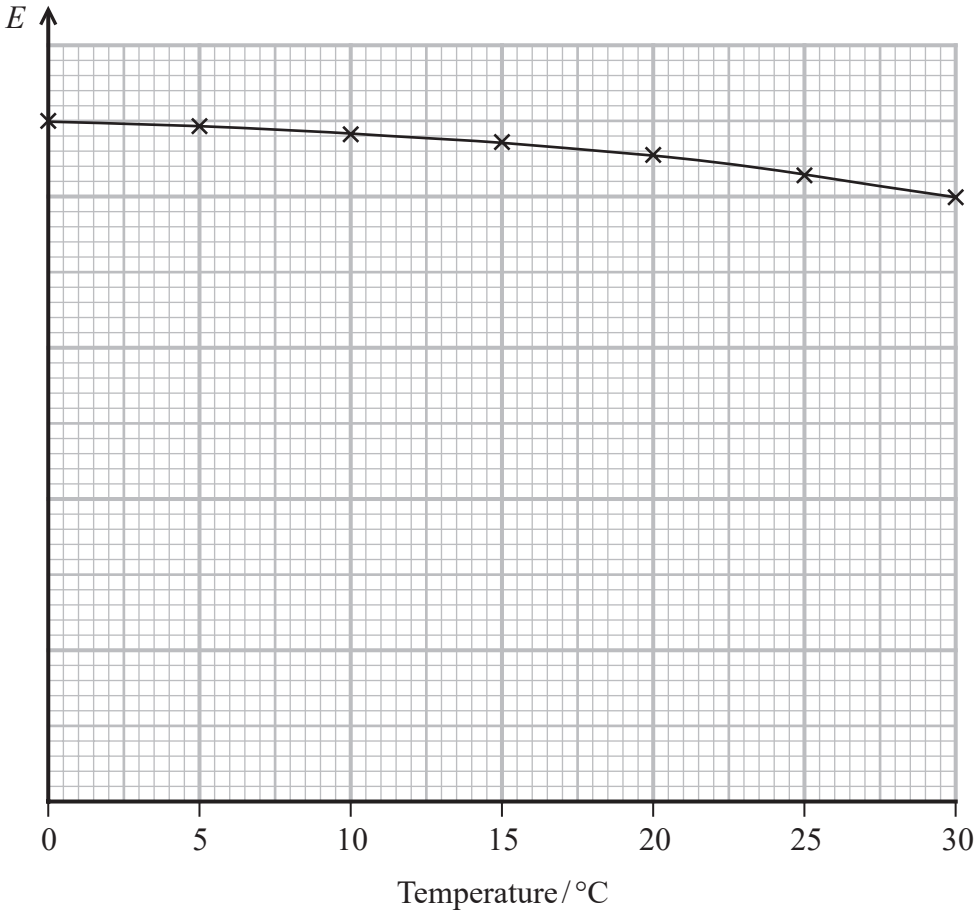
Calculate the tension in the string.

length of string = 41.0 cm

(4)

Tension in string = ...

(b) The graph shows how the Young modulus E of the nylon varies with temperature.



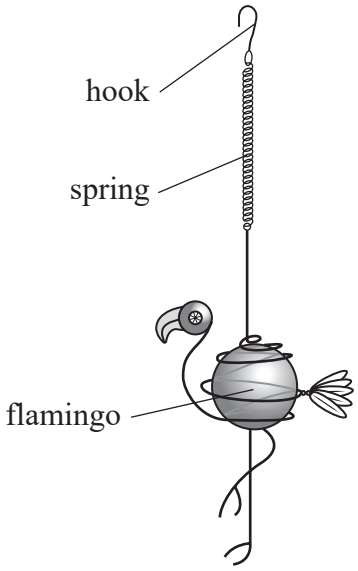
When the harp is played, the temperature of the string increases.

Explain how this temperature change would affect the frequency of the note produced when the string is plucked.

(3)

(Total for Question 18 = 9 marks)

20 A garden ornament consists of a metal flamingo suspended from a spring as shown. The spring is hung from a support using the hook.



(a) The mass of the flamingo is 65 g. When the flamingo is suspended vertically the spring extends by 8.5 cm.

The flamingo is pulled downwards by a small extra displacement and then released. The flamingo undergoes simple harmonic motion vertically.

The instructions state that the flamingo will oscillate with a frequency of 2.5 Hz.

Deduce whether this statement is correct.

(5)

(b) After being set into vertical oscillation, the flamingo comes to rest after a short time.

Explain why the flamingo comes to rest.

(2)

.....

.....

.....

.....

(c) In a slight breeze the flamingo swings from side to side and behaves as a simple pendulum.

(i) Show that the period of oscillation of the flamingo pendulum is about 2.2 s.

pendulum length = 1.25 m

(2)

.....

.....

.....

.....

(ii) The amplitude of oscillation of the flamingo pendulum is 7.5 cm.

Calculate the maximum velocity of the flamingo pendulum.

(3)

.....

.....

.....

.....

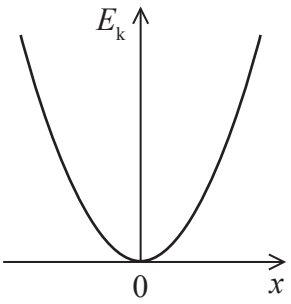
.....

Maximum velocity = ...

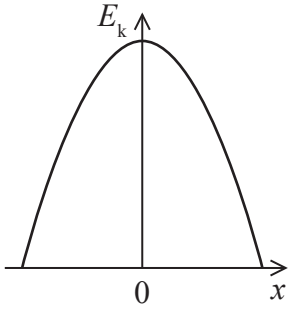
(Total for Question 20 = 12 marks)

9 An object oscillates with simple harmonic motion. The object has kinetic energy E_k and displacement x.

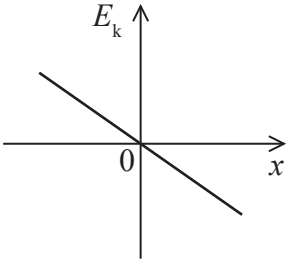
Which of the following graphs shows the variation of E_k with x for the object?



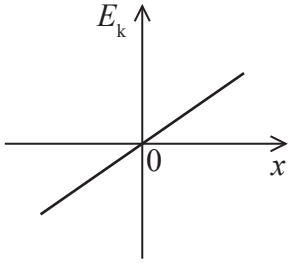
☒ **A**



☒ **B**



☒ **C**



☒ **D**

(Total for Question 9 = 1 mark)